Tanta University **4th year, Computers & Control Dept.**

Faculty of Engineering **Control and Instrumentation course**

CONTROL AND INSTRUMENTATION

LAB NOTEBOOK

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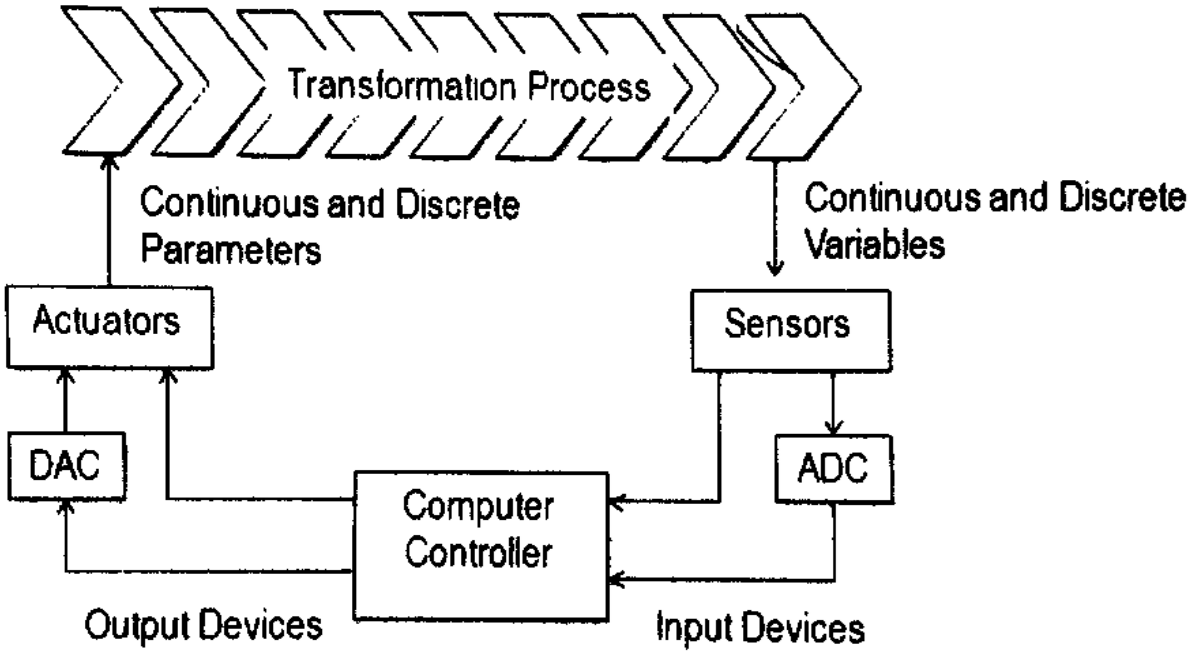
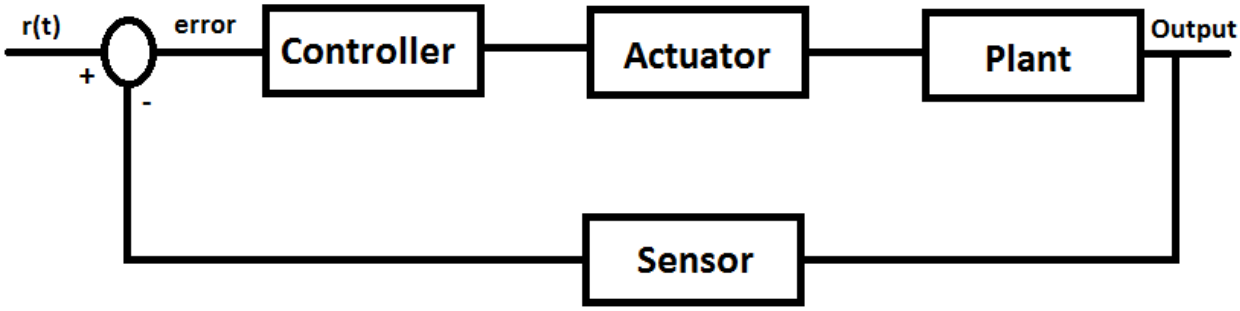
Contents

(1) Introduction to process control

- To implement process control, the computer / controller must collect data from and transmit signals to the production process.
- Components required to implement that interface:
  - Sensors: to measure continuous and discrete process variables.
  - Actuators: to drive continuous and discrete process parameters.





(2) Sensors:

- A sensor (also called detector) is a transducer that converts physical stimulus from one form into a more useful form to be easily measured.

(A transducer is any device which converts one form of energy from one form into another)

- Sensors examples:
    1. Temperature
    2. Proximity
    3. Photo
    4. Rotary encoder
    5. Pressure
    6. Hall
    7. Humidity
    8. Vibration

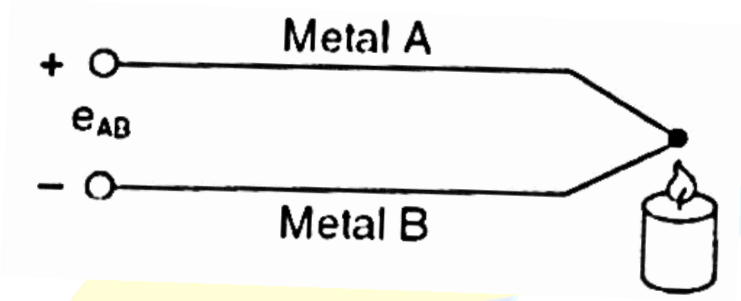
1- Ternperature sensor:

A Temperature sensor is used to sense and convert temperature into a readable output.

a) Thermocouple:

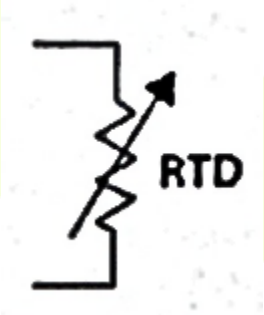
A thermocouple is a device that directly converts thermal energy into electrical energy When two dissimilar metal wires are connected at one end forming a junction, and that junction is heated, a voltage is generated across the junction (see the figure below). If the opposite ends of the wires are connected to a meter, the amount of generated voltage can be measured. This effect was discovered by Thomas

Seebeck, and thus named the Seebeck Effect or Seebeck coefficient. The voltage created in this situation is proportional to the temperature of the junction.



Resistance Temperature Detector (RTD):

RTD's employ the property that the electrical resistance of metals varies with temperature. They are positive temperature coefficient (PTC) sensors whose resistance increases with temperature. The main metals in use are platinum and nickel, RTD's are the most accurate sensors for industrial applications and offer the best long-term stability.



b) Thermistor:

Thermistors are inexpensive, easily-obtainable temperature sensors.

Thermistors are constructed of semiconductor material with a resistivity that is especially sensitive to temperature.

- Negative Temperature Coefficient (NTC) Thermistors exhibit a decrease in electrical resistance when subjected to an increase in temperature.
- Positive Temperature Coefficient (PTC) Thermistors exhibit an increase in electrical resistance when subjected to an increase in temperature.

Thermistors are less expensive than thermocouples, easy to use and adaptable. Circuits with Thermistors can have reasonable output voltages not the millivolt outputs thermocouples have. Because of these qualities, thermistors are widely used for simple temperature measurements.

2- Proximity sensor:

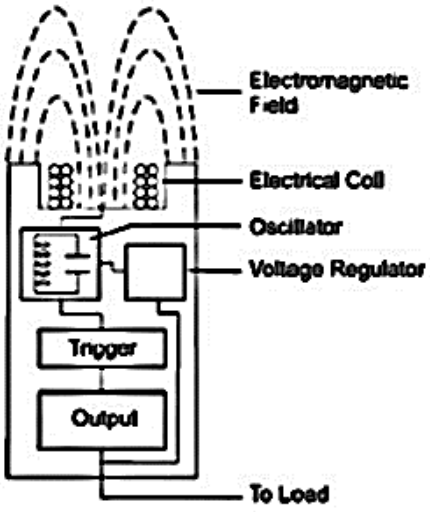
A proximity sensor is a sensor able to detect the presence of nearby objects without any physical contact. A proximity sensor often emits an electromagnetic field or a beam of electromagnetic radiation (infrared, for instance), and looks for changes in the field or return signal. The object being sensed is often referred to as the proximity sensor's target.

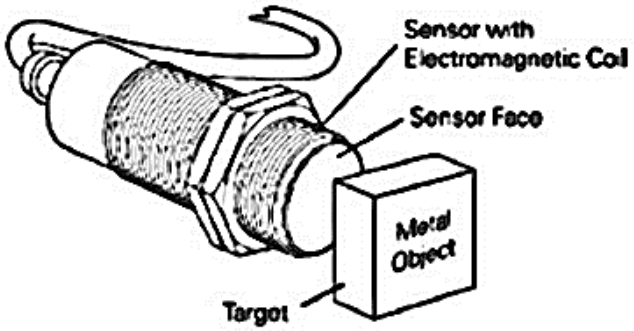
Different proximity sensor targets demand different sensors. For example, a capacitive or photoelectric sensor might be suitable for a plastic target; an inductive proximity sensor always requires a metal target.

- Inductive Proximity Sensor:

The inductive proximity sensor can be used to detect metallic targets only. The main components of the inductive proximity sensor are coil, oscillator, detector and the output circuit. The coif generates the high frequency magnetic field in front of the face. When the metallic target comes in this magnetic field it absorbs some of the energy. Hence the oscillator field is affected. This is detected by the detector, if the oscillation amplitude reaches a certain threshold value the output switches.

The inductive proximity sensor works better with ferromagnetic targets as they absorb more energy compare to non-Ferromagnetic materials. Hence operating distance for sensor is more for Ferromagnetic targets.

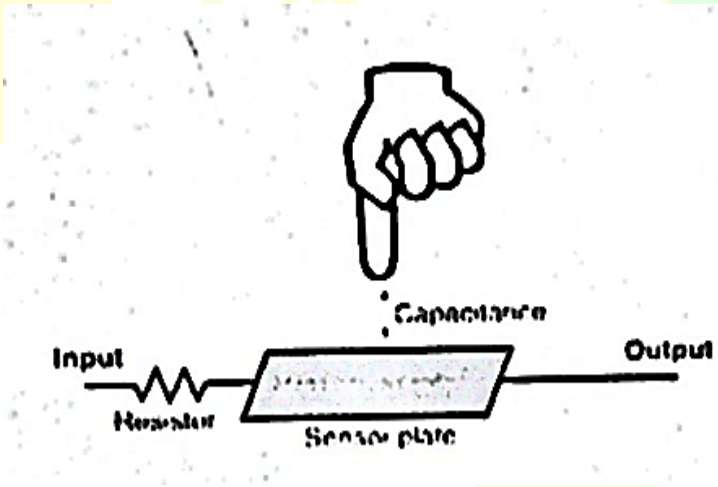




• Capacitive Proximity Sensor:

Capacitive proximity sensors can be used to detect metallic and also non-metallic targets like paper, wood, plastic, glass, wood, powder, liquid, etc... without physical contact. The capacitive proximity sensor works on the capacitor principle. The main components of the capacitive proximity sensor are plate, oscillator, threshold detector and the output circuit. The plate inside the sensor acts as one plate of the capacitor and the target acts as another plate and the air acts as the dielectric between the plates.

As the object comes close to the plate of the capacitor the capacitance increases and as the object moves away the capacitance decreases. The detector circuit checks the amplitude output from the oscillator and based on that the output switches.



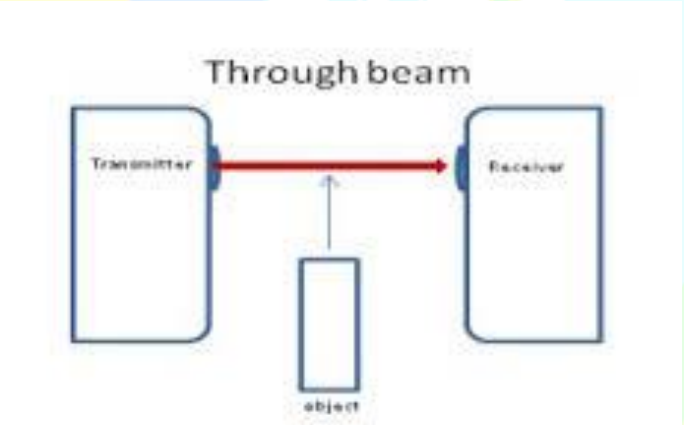
3- Photo sensor:

Photo sensors, also known as photo eyes, are electronic devices that are used to sense the presence or absence of an object by using a light transmitter, often infrared, and a photoelectric receiver.

There are different functional types: through beam, retro-reflective and diffuse sensors.

Through beam Sensors

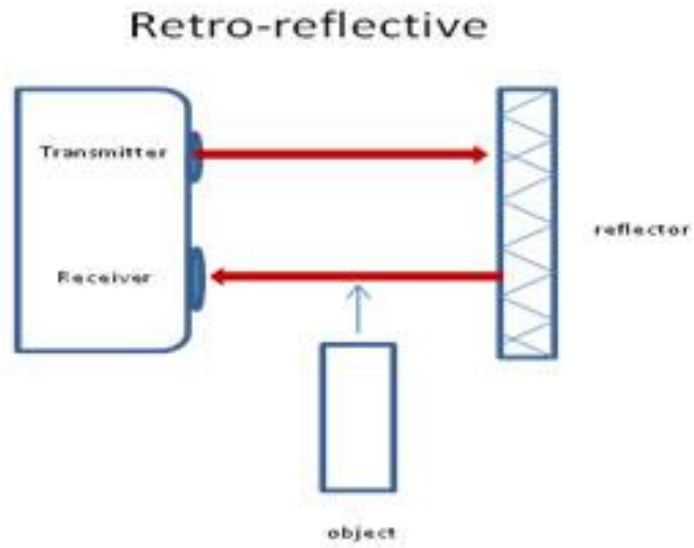
The principle relies on two separate housings, one for the transmitter and one for the receiver, with the transmitter providing a continuous beam of light to the receiver. Each time an object passes through the beam this interrupts the path between the transmitter and receiver, which in turn causes the receiver to send an electrical signal to the output.



Retro-reflective Sensors

Retro-reflective sensors are easier and less time consuming to install than through beam sensors. Because of this they are a popular choice within industry. Both the transmitter and receiver are contained within the same housing: all that is required is to position the reflector opposite to the sensor. The principle is like through beam in that detection occurs when there is an interruption of the light beam between transmitter and receiver. The reflector passes the

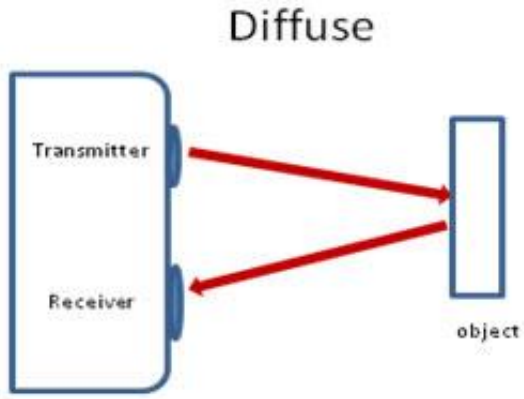
light beam back to the sensor until an object is present; this breaks the beam and causes the sensor to send an electrical signal to the output.



Diffuse Sensors

Diffuse sensors are the same as retro-reflective sensors in that both the transmitter and receiver are contained within the same housing: but all that is required is to position the object opposite to the sensor.

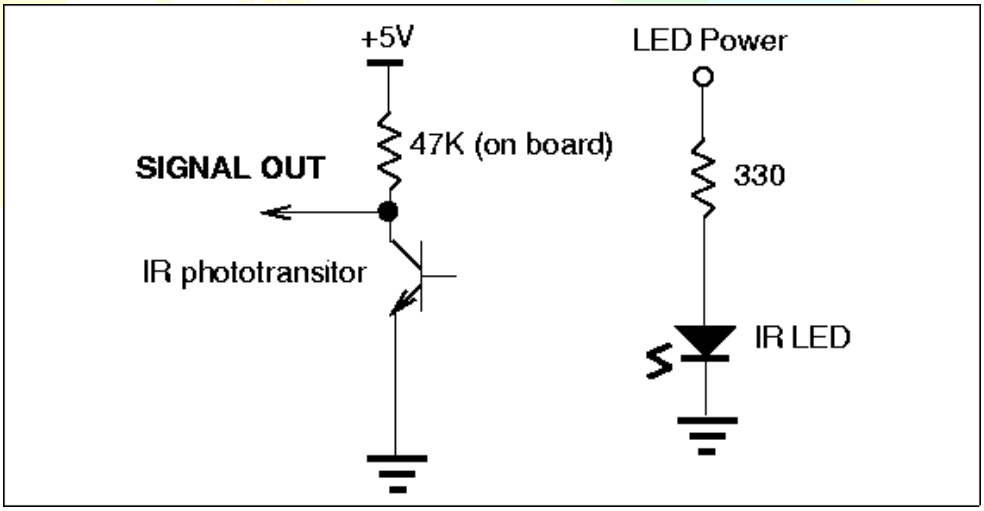
The principle is like retro-reflective in that detection occurs when there is an interruption of the light beam between transmitter and receiver. The diffuse object passes the light beam back to the sensor meaning that an object is present; this causes the sensor to send an electrical signal to the output. In case the object is absent, the light beam is scattered away and never back to the sensor meaning that the object is absent.



Examples:

- **Phototransistor:**

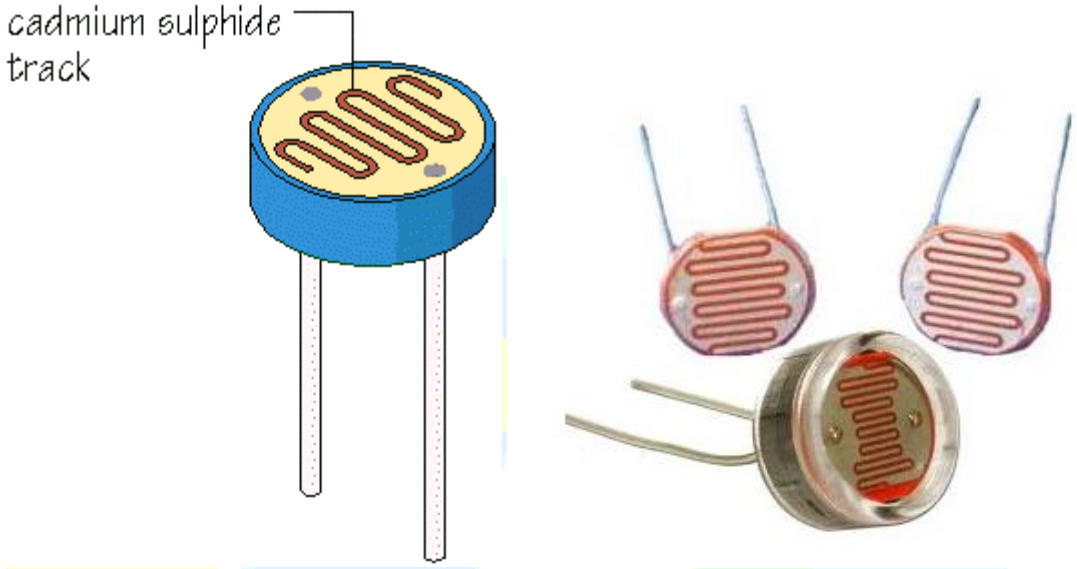
A phototransistor uses the level of light it detects to determine how much current can pass through the circuit. So, if the sensor is in a dark room, it only lets a small amount of current through. If it detects a bright light, it lets a larger amount of current through.



- **Light Dependent Resistors (LDR):**

LDRs is a light controlled variable resistor. The resistance of the LDR decreases with increasing incident light intensity; in other words, it

exhibits photoconductivity. The LDR can be applied in light sensitive detector circuits, and light and dark activated switching circuits.



4- Rotary Encoder:

A rotary encoder, also called a shaft encoder, is an electro-mechanical device that converts angular position or motion of a shaft or axle to an analog or digital code.

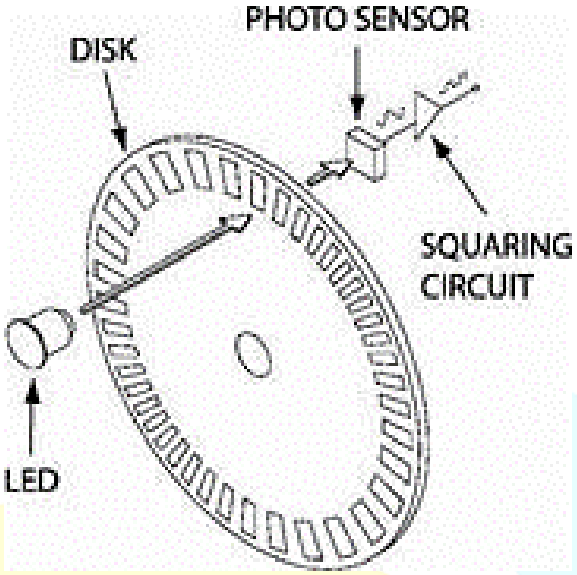
There are two main types:

- Absolute:

  The output of absolute encoders indicates the current position of the shaft, making them angle transducers.

- incremental (relative):

  The output of incremental encoders provides information about the motion of the shaft, which is typically further processed elsewhere into information such as speed, distance, and position.



5- pressure sensor:

A pressure sensor usually acts as a transducer; it generates a signal as a function of the pressure imposed.

Pressure sensors are based on a piezoelectric materials that generates electricity when subjected to a pressure change. Such piezoelectric materials, or transducers can convert a Pressure signal into an electrical signal that can be measured.

A pressure sensor measures pressure, typically of gases or liquids. Pressure is an expression of the force required to stop a fluid from expanding, and is usually stated in terms of force per unit area.

Pressure sensors are used for control and monitoring in thousands of everyday applications. Pressure sensors can also be used to indirectly measure other variables such as fluid/gas flow, speed, water level, and altitude. Pressure sensors can alternatively be called pressure

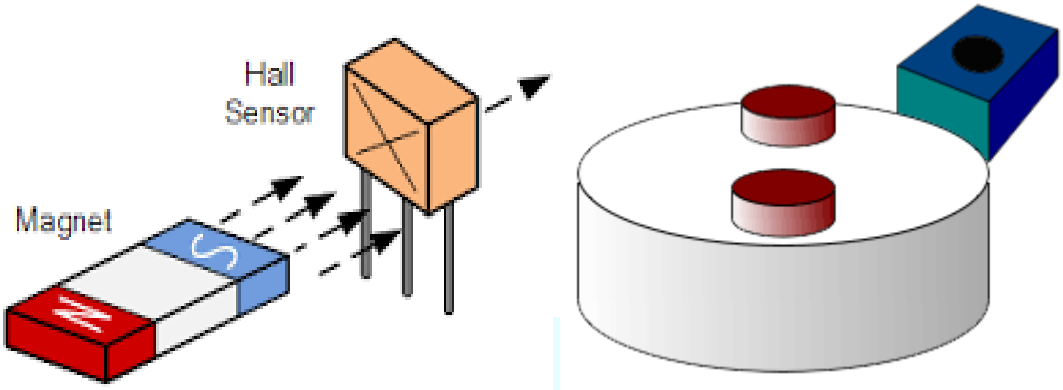
transducers, pressure transmitters, pressure senders, pressure indicators and piezometers, manometers, among other names.

6- Hall sensor:

A Hall effect sensor is a transducer that varies its output voltage in response to a magnetic field. Hall effect sensors are used for proximity switching, positioning, speed detection, and current sensing applications.

In its simplest form, the sensor operates as an analog transducer, directly returning a voltage. With a known magnetic field, its distance from the Hall plate can be determined and can be used to determine speed of motors.

The flow of electrons through a conductor is known as a beam of charged carriers. When a conductor is placed in a magnetic field perpendicular to the direction of the electrons, they will be detected by the conductor. Consequently, one plane of the conductor will become negatively charged and the opposite side will become positively charged. The voltage between these planes is called Hall voltage.



7- Humidity sensor:

A humidity sensor has a sensing portion which usually comprises a humidity-sensitive resistor composed of an organic polymer or plastic, such as a polyamide resin, polyvinyl chloride or polyethylene, or a metal oxide.

A humidity sensor measures the humidity level by measuring the change in the resistance of an element in the resistive type or the change in the electrostatic capacity of that element in the capacitive type as it absorbs or releases moisture.

8- Vibration sensor:

A vibration sensor is a microphone designed to be used for recording or listening to sound waves (also called vibrations) caused by pressure change. Most vibration sensors are based on a piezoelectric transducer that generates electricity when subjected to a pressure change. Such piezoelectric materials, or transducers can convert a vibration signal into an electrical signal since sound is a frequency wave.

Switches:

1- Push button

A push-button or simply button is a simple switch mechanism for controlling some aspect of a machine or a process. Buttons are typically made out of hard material, usually plastic or metal. The surface is usually flat or shaped to accommodate the human finger or hand, to be easily depressed or pushed. Buttons are most often biased switches, although many un-biased buttons (due to their physical nature) still require a spring to return to their un-pushed state. Different people use different terms for the "pushing" of the button, such as press, depress, mash, hit, and punch.

2- Limit switch

a limit switch is a switch operated by the motion of a machine part or presence of an object.

They are used for controlling machinery as part of a control system, as a safety interlocks, or to count objects passing a point. A limit switch is an electromechanical device that consists of an actuator mechanically linked to a set of contacts. When an object comes into contact with the actuator, the device operates the contacts to make or break an electrical connection.

3- Mercury switch

A mercury switch is a switch which opens and closes an electrical circuit when a small amount of the liquid metal mercury makes contact

with metal electrodes to close the circuit. There are several different basic designs (tilt, displacenent, radial, etc.) but they all share the common design strength of non-eroding switch contacts.

4- Reed switch

The reed switch is an electrical switch operated by an applied magnetic field. It was invented at Bell Telephone Laboratories in 1936 by W. B. Ellwood. It consists of a pair of contacts on ferrous metal reeds in a hermetically sealed glass envelope. The contacts may be normally open, closing when a magnetic field is present, or normally closed and opening when a magnetic field is applied. The switch may be actuated by a coil, making a reed relay, or by bringing a magnet near to the switch. Once the magnet is pulled away from the switch, the reed switch will go back to its original position.